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No. XXXI.

ON MEANS OF EXTENDING THE RAILWAY SYSTEM INTO EVERY PORTION OF THE UNITED KINGDOM.

May 1, 1844.

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THE subject of the first illustration for this evening has not been inappropriately chosen. This day the Great Western Trunk Railway to Exeter, 193 miles from London, has been opened throughout to the public, as also that from Norwich to Yarmouth, 18¼ miles in length; the latter is a single way, and is one of the first passenger-lines of so great a length constructed on this principle.

My attention was first drawn to the subject of railways in 1831, being consulted professionally in that year as to a proposed railway from Truro to Perran, in the county of Cornwall; since which period I have devoted much time to this important subject, and have been connected with some of the great lines now in full operation.

Before giving an account of the two economical systems of laying out railways, which I consider most likely to supersede the extravagant plans hitherto almost universally adopted, I will give a slight sketch of the rise and general progress of the railway system.

The success of the Stockton and Darlington Railway, originally intended to be worked by horse-power, and the first work of the kind executed, by Mr. Stephenson, caused the enterprising and wealthy people of Liverpool and Manchester to turn their attention to the subject of railways, and the consequence was the construction of the "grand experimental line between Liverpool and Manchester." The Leeds and Selby was the next in order; and the London and Birmingham, Grand Junction, and Great Western soon followed.

In the session of 1836, twenty-six railway acts were obtained, including the Birmingham and Gloucester, the Bristol and Exeter, the Hull and Selby, the North Midland, Manchester and Leeds, and York and North Midland. Four of the twenty-six have not been executed. In the same year, twenty-seven other railway schemes were laid before parliament, all of which were thrown out.

The rage for railways was, however, for a while completely checked, owing to the heavy deposit required to be made by parties intending to introduce railway-bills, added to the enormous estimates and extravagant system of executing railways, as practised by a few engineers who seemed to have the whole matter in their own hands, but who are now generally fully alive to the necessity of practising economy, and who, from the dearly bought experience of past years, are enabled considerably to reduce the original outlay, even with the "double way."

The following is a list of English railways in full operation :—

No.	Title.	Power Employed.	Length in Miles.
1	Aylesbury (single way)	Locomotive	7·00
2	Birmingham and Derby Junction	Locomotive	38·75
3	Birmingham and Gloucester	Locomotive	55·00
4	Bishop Auckland and Weardale	Locomotive	8·33
5	Bodmin and Wadebridge	Locomotive	14·75
6	Bolton and Leigh	Locomotive	9·75
7	Bolton and Preston	Locomotive	10·00
8	Brandling Junction............	Locomotive	23·00
9	Bristol and Gloucester	Locomotive	37·50

No·	Title.	Power Employed.	Length in Miles.
10	Canterbury and Whitstable	Stationary	6.00
11	Chester and Birkenhead........	Locomotive	15·12
12	Chester and Crewe	Locomotive	21·00
13	Clarence	Locomotive	32·50
14	Durham and Sunderland	Stationary	19·00
15	Eastern Counties and Northern and Eastern	Locomotive	82·50
16	Grand Junction	Locomotive	97·50
17	Great North of England........	Locomotive	45·00
18	Great Western (London to Exeter) and Cheltenham Branch......	Locomotive	220·00
19	Hull and Selby	Locomotive	30·75
20	Lancaster and Preston	Locomotive	20·25
21	Leeds and Selby..............	Locomotive	20·00
22	Leicester and Swannington	Locomotive	16·00
23	Liverpool and Manchester	Locomotive	31·00
24	London and Birmingham	Locomotive	112·25
25	London and Blackwall	Stationary	3·75
26	London and Brighton..........	Locomotive	51·00
27	London and Croydon	Locomotive	10·00
28	London and Greenwich	Locomotive	3·75
29	London and South Western	Locomotive	76·50
30	Gosport Branch from Bishopstoke	Locomotive	16·00
31	Manchester and Birmingham to Crewe	Locomotive	31·00
32	Manchester and Bolton	Locomotive	10·00
33	Manchester and Leeds	Locomotive	51·25
34	Maryport and Carlisle	Locomotive	20·00
35	Midland Counties	Locomotive	48·25
36	Newcastle and Carlisle	Locomotive	65·50
37	Newcastle and Darlington	Locomotive	22·50
38	Newcastle and North Shields....	Locomotive	6·75
39	North Midland	Locomotive	73·00

No.	Title.	Power Employed.	Length in Miles.
40	North Union	Locomotive	22·00
41	Norwich and Yarmouth (single way)	Locomotive	18·25
42	Preston and Wyre	Locomotive	22·00
43	Sheffield, Ashton, and Manchester (part completed)............	Locomotive	11·00
44	Sheffield and Rotherham	Locomotive	5·25
45	South Eastern, from Red Hill, Reigate	Locomotive	66·75
46	Taff Vale....................	Locomotive	30·00
47	Stockton and Darlington	Locomotive	35·00
48	Stockton and Hartlepool	Locomotive	8·00
49	Whitby and Pickering	Horse	24·00
50	York and North Midland	Locomotive	31·00
			1735·45

The following lines which I considered requisite to be continued for completing the railway system of England were laid down in my Railway Map of 1841 :—

	Miles.
From Newcastle to the East of Morpeth, Alnwick, and Belford, by Berwick and Dunbar to Edinburgh	117·00
From Lancaster, by Kendal, Orton, and Penrith, to Carlisle	70·25
From Darlington, by Richmond, Brough, and Appleby, to join the Lancaster and Penrith Railway at Penrith	62·00
From the Manchester and Leeds Railway at Todmorden, by Burnley and Blackburn, to Preston........	29·00
From Gloucester, by Ross, Monmouth, Abergavenny, Crickhowel, Brecknock, Trecastle, Llandovery, Llandilo-vaur, and Carmarthen, to Fishguard ..	130·00

	Miles.
From Ross to Hereford, Leominster, Ludlow, Bridgenorth, and Shiffnal	63·00
From Nottingham, by Newark, to Lincoln	35·00
From Bishops-Stortford to Cambridge	24·50
From Cambridge, by Peterborough, Market-Deeping, Bourn, Donnington, Lincoln, Gainsborough, Thorne, Snaith, and Selby, to York	140·75
From Market-Deeping, by Spalding, to Boston	22·00
From Cambridge, by Thetford, to Norwich	60·00
From Colchester to Ipswich, Woodhide, Saxmundham, Southwold, Lowestoft, and Yarmouth	64·00
From Colchester to Harwich	17·50
From Cambridge to St. Neott's, Bedford, Ampthill, Woburn, and Leighton Buzzard	48·00
From Aylesbury to Oxford	22·00
From York, by New Malton, to Scarborough, and Branch to Pickering	44·00
Chester and Holyhead	82·00
From Leeds to Bradford	13·50
From the Grand Junction Railway, by Wolverhampton, Shiffnal, and Wellington, to Shrewsbury	32·00
From Shrewsbury, by Oswestry, Chirk, and Ruabon, to Chester	42·00
From Shrewsbury, by Welsh-pool, Newton, and Llanidloes, to Aberystwith	63·00
North Kent, from the Greenwich line at Deptford, by Gravesend, to Stroud	30·00
From the South Eastern Railway to Canterbury, Ramsgate, and Margate	33·00
From Ashford, on the South Eastern Railway, to Rye, Winchelsea, Hastings, Bexhill, East Bourn, Seaford, Newhaven, and Brighton	46·00
From Shoreham to Worthing, Arundel, Chichester, Havant, and Fareham, to the Portsmouth Junction Railway	41·00

	Miles.
From Salisbury to Heytesbury, Warminster, Frome, and Bath	39·00
From the South Western Railway, near Winchester, to Salisbury, Blandford, Dorchester, Bridport, Axminster, Honiton, and Exeter	109·00
From the Bristol and Exeter Railway, near Exeter, to Oakhampton, Launceston, Bodmin, St. Austel, Truro, Penryn, and Falmouth	106·00
From Crediton, on the proposed Devon and Cornwall Line, by Chudleigh, South Molton, and Barnstaple, to Ilfracombe	39·00
	1624·50

Several of the above-mentioned lines have been sanctioned by the legislature, viz.

Berwick to Edinburgh.
Lancaster to Carlisle.
Chester to Holyhead. Also,
Exeter to Plymouth (not laid down in the map above alluded to).

The lines included in the foregoing list which have been opened for traffic are

Darlington to Newcastle.
Steventon to Oxford.
South Eastern to Maidstone.

The following lines in Scotland are now in operation :—

Title.	Power Employed.	Miles.
Arbroath and Forfar	Locomotive	15·00
Ardrossan and Johnston	Locomotive	5·50
Ballochney	Locomotive	6·00
Dundee and Arbroath	Locomotive	16·75
Dundee and Newtyle	Locomotive & Stationary	12·00
Edinburgh and Dalkeith	Horse	8·25
Edinburgh and Glasgow	Locomotive	46·00
Edinburgh and Newhaven	Locomotive	2·00
Garnkirk and Glasgow	Locomotive	8·00
Glasgow, Paisley, and Ayr	Locomotive	51·00
Glasgow, Paisley, and Greenock	Locomotive	22·50
Paisley and Renfrew	Locomotive	3·00
Slammannan	Locomotive	23·00
		219·00

The following still require to be made to complete the main lines of railway communication in Scotland :—

	Miles.
From near Falkirk (on Edinburgh and Glasgow Railway), by Stirling and Dumblane, west of Ochill Hills, to Auchterarder, and thence to Perth, and from Perth, by Errol, to Dundee	65
From Arbroath and Forfar Railway to Brechin, west of Laurence Kirk and Stonehaven, thence to Aberdeen	45
From Aberdeen, by Kintore, Inverury, Huntley, Keith, Fochabars, Elgin, and Nairne, to Inverness ..	100
	210

The following lines in Ireland are now in operation :—

Title.	Power Employed.	Miles.
Dublin and Kingstown..........	Locomotive	6·00
Extension to Dalkey............	Atmospheric	1·75
Dublin and Drogheda	Locomotive	30·00
Ulster (as far as Portadown)	Locomotive	25·00
Cork and Passage	Horse	6·00
		68·75

The following are the lines which are considered necessary to complete the railway communications of that kingdom :—

	Miles.
Extension to Bray and Wicklow	24·00
Dublin, by Naas, Athy, and Carlow, to Kilkenny	73·00
From Carlow, by Enniscorthy, to Wexford	42·00
Dublin, by Navan, (26½), Carrickmacross, to Armagh..	80·00
Armagh to Coleraine	56·00
Navan, by Kells, Virginia, Cavan, Enniskillen (65), Lifford, to Londonderry (50)	115·00
From the Dublin and Kilkenny Line (16 miles from Dublin), by Portarlington, Maryborough, Holy Cross (32) and Limerick (18), to Tarbut, on the south bank of the Shannon	148·50
From Holy Cross (83 miles from Dublin), by Cashell, Michelstown, Mallow (53), to Cork (18)	71·00
From north of Cork (48 miles from Dublin), by Macroon, to north side of Bantry Bay	64·00
From Waterford, by Carrick-on-Suir and Clonmell, to join the Dublin and Limerick Line (98½ miles from Dublin)	51·00

From the Dublin and Limerick Line, near Colbridge, (16 miles from Dublin), by Mullingar (36½), Athlone, and Galway (47½)	112·00
From Mullingar (52½ miles from Dublin) by Longford 26½) and Carrick-on-Shannon (20), to Sligo (28½)	75·00
	911·50

The British railways, therefore, at present in operation extend over 2023·20 miles, as follows:—

	Miles.
In England	1735·45
In Scotland	219·00
In Ireland	68·75

To complete the railway communication of the United Kingdom, as already proposed, there is a general extension required of 2745·50 miles, as follows:—

	Miles.
In England	1624·50
In Scotland	210·00
In Ireland	911·00

So that but half the extent of railway communication that may be expected is at present in operation. To complete the main British lines, therefore, it will require the sum of 41,182,500*l.*, even taking 15,000*l.* a mile as an average estimate.

In order to keep the cost per mile at a maximum of 15,000*l.*, I propose that all future railways should be either executed according to the reciprocating plan, or a modification thereof, or by the atmospheric plan, unless some other still more economical system should be discovered.

Reciprocating Plan.

In 1839, I laid my plan of working single lines before the Institution of Civil Engineers; and, in 1840, after completing a detailed survey of all the railways of the United Kingdom, and making practical experiments to the extent of 5,000 miles as to the working of the trains on all the British railways at that time open to the public, revised and corrected my plan, and then submitted it for the consideration of the public. Since that period, the "single way" has made considerable progress, and engineers are now laying out some of the principal lines on this plan in a modified form.

The mode of working a railway by this plan, with any amount of traffic, may be thus described :—

Suppose the distance between the terminal and the nearest principal intermediate station, and between the two principal intermediate stations to be twenty miles respectively, this distance is made up of two engine-runs of equal length meeting together at the half-way stations.

To illustrate the mode of exchanging the trains, which takes place at the exchange stations nearly simultaneously every hour, we need only describe this process between one of the terminal stations and the first principal intermediate station. An engine (No. 1) starts from the terminal station A, and another (No. 2) from the first principal intermediate station D, as the clock strikes 8, at an average speed of 25 miles an hour, including stoppages, the engines Nos. 1 and 2 will arrive by 24 minutes after 8 at the exchange station C, where each engine-run is furnished with a large turn-table, capable of holding the engine and tender together; an engine (No. 3) is already on the up-line ready to proceed with the up-train, and another (No. 4) on the down-line ready to proceed with the down-train. The engines Nos. 1 and 2, which have just arrived, are turned into the engine-sheds on either side, and the engines Nos. 3 and 4 are connected with the up and down-trains respectively, and proceed forward precisely at 8h. 30m., there being 6 minutes (for the sake of example) allowed for the exchange, for attaching or detaching carriages, &c., and for receiving and disembarking passengers. At 8h. 54m. engine No. 3 with the up-train will reach the arrival platform of the terminal station A, where the passengers and luggage will be despatched by omnibuses, &c. In the mean time the 9 o'clock down-train is preparing to start with engine No. 5, which has its steam up, and is waiting for the 9 o'clock bell to be rung, or bugle sounded. The clocks at each station throughout are required to be of uniform construction and by first-rate makers, and regulated twice in 24 hours by means of the electro-galvanic telegraph, which is considered a necessary appendage to all main lines of railway. At 24 minutes past 9, engine No. 5 will arrive with the second down-train at exchange station C, and engine No 6 will also arrive, within a minute before or after, with a second up-train at the same station; as on the first exchange, so again engines Nos. 1 and 2 are ready to proceed, on the signal being given at 9h. 30m., with the up and down-trains respectively. Engines Nos. 5 and 6 are turned into the engine-sheds as before, and prepared to make the next exchange; at 9h. 54m. engine No. 1 arrives at the terminal station A, as before, and engine No. 3 is again ready to start with the 10 o'clock train, and so the reciprocating process is continued throughout the 24 hours at each of the intermediate exchange stations.

Intervals of one hour each for the starting of the trains, and also ten-mile runs, are taken for the sake of easy illustration; but intervals of 90 minutes, which would give 16 daily trains, and longer runs according to each particular case, would answer equally well.

The estimated cost of constructing and finishing completely a line 60 miles in length, through a difficult country, taking the prices throughout on a liberal scale, including stations, furnishings, plant, &c. is 926,107*l.* 8*s.* 2*d.*, or altogether at the average rate of 15,435*l.* 2*s.* 5*d.* per mile.

The Atmospheric Plan.

An experimental line on this principle was laid down at Wormwood Scrubbs, on an embankment formed near the crossing of the Great Western Railway for the Birmingham, Bristol, and Thames Junction line, now called the West London Railway.

The length of this line was about half a mile, the two inclinations respectively on which the vacuum pipe was laid are 1 in 120 and 1 in 115; the diameter of the pipe was 9 inches internally; the exhausting pump 37½ inches diameter, with a stroke of 22½ inches. The pump was worked by a 16-horse power steam-engine.

Most railway engineers visited this line, and some of the most eminent have expressed a very favourable opinion of the suitableness of the system to difficult districts of country, and also to lines of frequent passenger traffic. Mr. Pim, treasurer of the Dublin and Kingston Railway, in a letter to the Right Hon. the Earl of Ripon, President of the Board of Trade in 1842, observes:—

"In practice, and to work economically, it will be sufficient to produce an exhaustion of air in the pipe equal to causing a pressure from the atmosphere, upon or behind the travelling portion, of 8 lbs. per square inch, which is only about one half of the pressure due to a vacuum. Supposing the main pipe to be of 18 inches internal diameter, it will receive a piston of 254 superficial inches area, on which, with the above pressure, a tractive force of 2032 lbs. is consequently obtained, and this is capable of propelling a train weighing 45 tons (say 8 or 9 loaded carriages) at the rate of 30 miles an hour, up an acclivity of 1 in 100, or 53 feet per mile.

" The composition has stood the effect of exposure to the seasons and of continued use for nearly 18 months.

" The tallow lining of the pipe produces a smoothness over its interior infinitely cheaper, and probably more effectual, than the most finished boring.

" When it becomes necessary to stop or retard the carriages, in addition to the use of a common break, a valve in the travelling piston may be opened by the guard of the train, whereby the external air being admitted, in advance of the piston, into the exhausted portion of the pipe, the propelling power is brought under perfect control.

" The separating valves in the main, between each section or division of a line, may be made self-acting, so that there will be neither occasion to stop nor even to retard the movement of a train in passing from one division of the pipe to another on an extended line, as the air is necessarily exhausted by the stationary power placed at the proper interval ; the carriages, may therefore, pass continually at any required velocity as if drawn by a locomotive engine, whereas by all other systems of traction derived from stationary power, a stoppage and change at each engine is unavoidable.

" The great advantage," continues Mr. Pim, " of the atmospheric system will be to obviate the waste of power and consequent absorption of profits arising from transporting useless weight and overcoming unnecessary friction."

"If," say Messrs. Samuda (the patentees of the present atmospheric railway), "for sake of argument, the expense of working the Birmingham Railway were to remain unaltered, but by the adoption of some other mode of obtaining power, the necessity of carrying the locomotive engine and tender (say 20 tons) with each train was obviated, the company would be able to transport with each train, for the same cost as at present, 20 tons gross, say 15 tons nett, of profitable merchandize additional, which, at 2*l.* per ton, would add to the revenue 30*l.* per journey, or about 225,000*l.* a-year, equal to an additional dividend of 5*l.* per cent to the subscribers."

The atmospheric plan as above described has been carried out between Kingston and Dalkey in Ireland, the safe working of which is aided by the electric telegraph of Messrs. Cook and Wheatstone.

The experimental line at Wormwood Scrubbs I examined with a view of ascertaining the state of the junctions of the main after considerable traffic had been on it.

I also travelled to and fro on the line, and found the motion easy while moving at a considerable speed.

It appears to me that the greatest difficulty in the practical application of the system to new lines will be in keeping the joints of the main perfectly sound on embankments, owing to the great subsidence which takes place in these works for a very long time after the permanent rails are laid.